RECREATIONAL BENEFITS TRANSFER PROJECT

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CHAPTER 1

INTRODUCTION AND OVERVIEW

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Introduction and Overview

This report summarizes the research completed under EPA Cooperative Agreement # CR813564 entitled "Recreational Benefits Transfer Project." The objective of this research was to review all travel cost recreational demand models completed between 1970 and 1986 from published and unpublished sources, including all Master's and Ph.D. essays that could be identified and obtained. From this literature a subset of the studies was assembled for meta-analysis. The meta-analysis sought to develop a statistical summary of the results from these demand analyses in order to determine the influences of judgmental and site-characteristic variables on the consumer surplus estimates derived and to gauge the effect of these variables on other measures of demands for recreational sites. This project was funded under the Innovative Benefit Analysis Program because the effort was viewed as exploratory. The primary research activities were undertaken jointly with Dr. Yoshiaki Kaoru, currently an Assistant Social Scientist at Woods Hole Oceanographic Institution. At the time, Dr. Kaoru was a graduate student in the Department of Economics at Vanderbilt University.

As the papers prepared under this agreement indicate, the research was quite successful. Statistical summaries were developed for some 77 different demand studies for recreational resources, and we compared the relative importance of variables describing modeling judgments with characteristics of the recreational sites and the activities undertaken at them. Four papers were prepared with partial support from this Cooperative Agreement. Two of the papers describing our approach have been presented at several universities in the United States, as well as at Academia Sinica in Taiwan and at a National Bureau of Economic Research (NBER) Conference on Data Needs for Economic Policy Making.

One of the papers is to be published in a volume from the NBER conference. The remainder are currently under consideration for publication. Two have received preliminary indications of publication interest, pending suggested revisions.

Rather than rewriting the materials developed from the research papers in an alternative technical format, this report is organized into four chapters following this introductory chapter, which highlights the overall conclusions of the research. Chapter 2 presents the first paper prepared from the research. It describes the conceptual issues associated with using meta-analysis to summarize estimates of the consumer surplus per unit of use across a diverse range of travel cost demand studies and summarizes the findings from our analysis. Chapter 3 focuses on a subset of the studies used for the meta-analysis of per-unit benefit measures and considers the feasibility of summarizing the estimates for other features of recreation demand (such as the price elasticity). We used a subset here because it was not always possible to estimate these price elasticities with the information reported in many of the recreation demand studies.

Because consumer surplus and price elasticity estimates are themselves random variables, Bockstael and Strand [1987] have emphasized the importance of incorporating their properties as estimators into policy analysis. Our use of the Newey-West [1987] adjusted covariance matrix in evaluating the effects of modeling assumptions was one reflection of this influence. Chapter 4 was an unanticipated byproduct of the theoretical analysis of the properties of our consumer surplus estimators. It proposes a new estimator for developing consumer surplus estimates and evaluates it with some sampling experiments for a particular specification of the travel cost demand model. This estimator offers an alternative to the proposal recently advanced by Adramowicz et al. [1989] for cases with unstable consumer surplus estimates. Chapter 5 places our findings

in a somewhat more general context, as part of an evaluation of new data needs for environmental policy making.

Several overall conclusions emerged from our research activities. They can be categorized into three broad areas.

A.   Conceptual Findings

Our theoretical analysis of the issues associated with measuring consumer surplus suggested that virtually all consumer surplus estimates will be biased. This follows because they usually involve nonlinear transformation of estimated demand parameters. As a consequence of Jensen's inequality, the consumer surplus estimates themselves exhibit bias even if the specification for the demand model is correct.   Specification errors in demand analysis simply compound the difficulties raised by the nonlinear transformation. This implies that general purpose strategies designed to focus on estimating demand models that serve a variety of purposes or reliance on the existing literature wherein demand analyses are developed to serve other purposes (test hypothesis, illustrate new functional forms or estimators, or highlight the special features of a particular data set) are not necessarily the best suited for environmental benefit estimation.   These objectives may not be consistent with deriving the most robust benefit measures. While this general conclusion was probably recognized by most researchers in this area, to our knowledge this point has not been specifically made in the literature.

This point applies not only to the literature on travel cost recreational demand models, but to all current techniques in use for measuring recreation benefits, including the more recent random utility models whether based on logit or nested logit specifications.   In all cases, the benefit measures involve a nonlinear transformation of random variables, which in itself will induce bias

in the welfare estimates. This suggests that new research in the area should consider the implications of modeling and estimation strategies specifically designed to accomplish a broad range of benefit estimation tasks. Research on the implications of bottom up versus top down estimates for aggregate benefit measures, as well as on the development of "transferrable" models for measuring consumer surplus (as opposed to the demand features of recreational resources), seems highly appropriate. Equally important, as Chapter 4 illustrates, it is possible to develop estimators designed to focus on consumer surplus measurement instead of estimation of demand parameters. While this work is largely illustrative, it nonetheless displays how the performance of alternative estimation strategies can be sensitive to the features of the true demand structure and the objectives of the analysis.

A further set of conceptual issues resulting from the research arises from the meta-analysis. Here we found strong confirmation for systematic variation in the consumer surplus estimates per unit of use across a wide range of studies. This systematic variation could be attributed to both the features of the resources involved and the modeling decisions made in estimating the travel cost demand models for these recreational resources. Indeed, the most important factors we found bore a close correspondence to the issues identified in the literature as the most significant questions in modeling recreation demand. Thus, the empirical analysis provides strong confirmation for the implicit research agenda that has evolved in recreational demand modeling.

B.   Empirical Findings

The empirical analysis suggest that it is possible to summarize both the consumer surplus estimates per unit of use and the own-price elasticity of demand for recreation sites across a wide range of studies. These estimated models

include variables for the features of the recreation sites, as well as the modeling judgments made in developing each of the demand estimates. After adjustment for the panel nature of our sample data set, the results display a remarkable degree of consistency and robustness across alternative specifications. While these are not predictive equations in the sense that they provide a mechanism for predicting the consumer surplus per unit of use that would arise for each type of recreation site, they can be used as approximate gauges of the plausibility of estimates derived from transfer exercises or from specific studies for individual sites. Perhaps most importantly, they provide a basis for judging the degree of maturity in travel cost recreation demand models. By appraising the relative importance of judgmental versus theoretically motivated variables, this type of analysis evaluates how much our current estimates are influenced by factors that arise from a priori theory versus those which represent analysts' adjustments to take account of incomplete data or modeling assumptions required for meta-analysis.

C.   Benefit Transfer Findings

In addition to the first two categories of results, the analysis also has implications for the process of developing transferrable benefit estimates. The most important of these implications is the demonstration that unifying principles connect quite diverse estimates across modeling efforts and widely varying recreation sites. Because these modeling efforts were undertaken by different investigators at very different times with diverse amounts of information, this is reasonably strong support for a set of unifying principles connecting the per unit valuation measures for a wide range of recreational resources.

The meta-analysis also forces the analyst to consider the measure used as

the focus of an empirical summary. We considered two -- the consumer surplus per unit of use and the own-price elasticity of demand. Either could provide the basis for a benefit transfer analysis used in a policy evaluation.

Analysts have tended to use a unit value approach to benefit transfer, treating the model transfer task as one involving the development or transfer of a per unit value appropriate to the policy and then dealing with the number of people and units of use affected by the policy as a separate question. By forcing the selection of a metric for summary, meta-analysis has identified that consumer surplus per unit of use need not be the focus for a benefits analysis. The early benefit-cost analyses of Harberger [1971] and, indeed, current evaluations of the effects of cost-reducing technological innovations in agriculture (following Griliches [1957] early methodology for hybrid corn) rely on point estimates of demand and supply elasticities. We could easily consider the use of a price elasticities/local approximation approach to estimating the benefits from a policy improving access to a recreation site (i.e. where the change could be viewed as a price change).

Equally important, there is a general issue of how we wish to prepare these summaries. Chapter 2 suggests that for well-behaved demand functions, we have little intuition about the properties of the consumer surplus per unit to use in judging the plausibility of differences in estimates across alternative studies. Both conceptual and empirical research is needed here.

Finally, perhaps the most important conclusion for benefits transfer arises from the inadequacy of the reporting standards used in most published research. Because this is unlikely to change. in the near future, a reorientation in the research and data acquisition in support of benefit analysis for policy purposes is clearly warranted. More specifically, policy offices need to establish groups that summarize in a format consistent with the needs of a meta-analysis the

findings of new empirical studies ~~as they are available.~~ By establishing a consistent protocol for these summaries, it would be possible to request from researchers at the time their unpublished or published reports become available the companion supplementary information needed for meta-analyses. Usually these are summary statistics for the variables used in the study, descriptions of transformations, sample characteristics, clarifications, etc. When the study is recent, this information is easily available from researchers, does not require that they furnish their complete data (which may be planned for use in future research).   It is also a more manageable enterprise.   After a lapse of time and the completion of the policy task, these requests are less likely to be responded to and, in most cases, the timing does not permit a response.

As policy analyses increasingly rely on using research developed for other purposes and research available on the proverbial "research shelf," it is clearly essential that analysts set up mechanisms to "define the shelf and maintain it." With limited resources and an increasing number of policies to be evaluated, EPA and other mission-oriented agencies have concluded that they cannot afford to support research that does not have an immediate policy relationship. This means they must choose the most important questions for these limited investments and rely on information from the performing community for all the rest. While an understandable response, it reinforces the need for research on how to archive what is being done so it can be systematically used for future policy evaluations.   A meta-analytic approach forces the systematic collection of information as it is developed. Examples of its use for policy issues (outside economics) are now making the popular press. For example, the July 1, 1989 issue of The New York Times reported the results of a study indicating a narrowing in the traditional differences in verbal and mathematics aptitude scores between

men and women. It was based on a meta-analysis of different researchers' studies of these groups' test performances over a number of years.

Increased availability of data, the extensive increase in contingent valuation surveys for a wide range of environmental resources (see Mitchell and Carson [1989]), and enhancements in micro-computing together make this task a reasonably straightforward data management effort. Without this effort, benefits transfer will remain a haphazard and last-minute enterprise that is not fully informed by available research. As such, it progressively will lose professional credibility and fail to systematically learn from past experience.

CHAPTER 1

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CHAPTER 2

SIGNALS OR NOISE? EXPLAINING THE VARIATION

IN RECREATION BENEFIT ESTIMATES

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Signals or Noise? Explaining the Variation in Recreation Benefit Estimates

V. Kerry Smith and Yoshiaki Kaoru*

I.   Introduction

This paper proposes a new method for taking stock of what we have learned about the benefits users derive from environmental resources. Our approach uses econometric methods to review the literature. While we have applied this approach to one class of benefit estimates--empirical studies using the travel cost method to estimate the demand for specific recreation sites, it has general relevance for gauging what has been learned by empirical research in many other areas of **economics.**[1]

The research landscape for benefit estimation has changed dramatically in the ten years since Freeman wrote his influential overview of the field. Freeman described the motivation for his book as a response to a gap in the literature on benefit estimation. As he noted, by 1979 there had been "...substantial research effort devoted to developing a rigorous and unambiguous definition and measure of changes in welfare at the theoretical level..." but "...relatively little concern for translating the theoretical concepts and definitions into usable, operational empirical techniques" (p. 15). This situation has changed, especially for applications in the United States.   Of the 77 travel cost recreation demand studies analyzed in this paper, 61 were prepared since 1980. Mitchell and Carson identified over 120 contingent valuation studies, most of which were completed after 1980. A similar pattern emerges for hedonic property

value studies: of the 35 including information on air pollution, 30 were available after 1980. Certainly the increased role given to benefit-cost analyses for evaluating environmental policies in Executive Order 12291 (issued in February 1981) has contributed to the dramatic expansion in this literature (see Smith [1984] and Office of Policy Analysis, U. S. EPA for evaluations). Nonetheless, the available benefit estimates fall short of what is needed for an increasing array of policy related activities (see Ward and Loomis; Naughton, Parsons, and Desvousges). Indeed, the practice of adjusting the results from one or more existing studies for a specific type of environmental resource and using them to value changes in another resource has become a growing area for research. Labeled as "Benefits Transfer," this process usually involves two steps: (1) adjusting or transferring an estimated model (or set of per unit benefit estimates) from the situation where it was developed to the new application; and (2) developing an aggregate estimate for the relevant population from per unit estimates and other assumptions. While judgment plays an important role in both steps, it has been the principal basis for the first step. Many of the published sources used for benefit estimates in policy analysis were not designed to provide measures of the benefits for a change in the quantity or quality of a resource. Rather, they were developed to introduce a new model, test a hypothesis, evaluate the implications of specific assumptions, or illustrate a "new" estimator. Consequently, they must be adapted for benefit measurement. The nature of these modifications depends upon both the benefit estimation task and the information reported in the original sources.

Our findings show a systematic relationship between the estimates and the features of the empirical models. We found that both the type of recreation site involved and the assumptions made in developing the empirical models were

important to the results. We classified the variables used to describe models according to whether they attempted to reflect specific theoretical issues associated with individuals' recreation decisions or analysts' judgments needed to estimate a model (e.g., selecting a functional form for the demand model or making assumptions to compensate for inadequate data). Ideally, the latter variables would not be important determinants of the variation in benefit estimates. We found that they are.

The specific factors found to be significant determinants of the real consumer surplus per unit of use have direct implications for research on households' recreation decision-making; for further uses of the travel cost demand model; and for the practices used in transferring benefit estimates derived from this class of models to new applications. We describe these implications in the last section of the paper, after developing the background for this approach in Section II and describing the data set as well as our results in Section III.

II. The Role for Statistical Methods in Developing a Research Synthesis

A. Background

The use of statistical methods to develop a research synthesis has a long history. Most of these applications have involved controlled experiments in psychology, education, or the health sciences. They have focused on consistently aggregating the results from different controlled experiments. In these cases, the methods are motivated by the desire to avoid the subjective nature of most research reviews. At best, the conventional literature review summarizes the presence or absence of statistically significant effects and, in some cases, compares the size of estimated effects. While many of these studies have

attempted to draw some "bottom line" conclusions about what is known (as Light and Pillemer observed), these appraisals often violate simple statistical principles in distilling an admittedly complex array of work. Moreover, to develop this type of summary, the reviewer usually must adapt the multiple (and often complex) features of the studies to fit some comparable format in order to propose a consensus judgment.

Because empirical research in economics is usually not based on experimental data and may well report multiple models applied to a single data base, our proposed methodology is different from that used in most meta analyses (see Cordray). It must reflect both the modeling judgments (made because controlled experiments are usually impossible) and the interdependent panel nature of any sample of research results. Fortunately, both issues can be addressed with existing econometric methods.

Moreover, the rationale for using an econometric framework for synthesizing the benefit estimates for environmental resources is more general. Empirical models are combinations of prior theory and analyst judgment. That judgment combines at least four elements: the problem or issue the empirical model seeks to address (e.g., test a hypothesis or estimate a specific parameter or quantity); the economic theory of behavior assumed to be relevant to the problem; the data available to estimate the model; and the learning that accompanies evaluating the joint effects of functional specification, variable construction, and the results from prior model formulations in relationship to the existing literature.

The last of these, sometimes referred to as specification searches or data mining, has been widely criticized in the recent econometric literature. We do not intend to repeat that discussion here. Rather, by viewing models as

approximations, we have further motivation for using statistical summaries of the results from existing models to evaluate the importance of such compromises for the findings.

B.   A Simple Yodel for Describing Recreation Demand Structure

The travel cost recreation demand model can be described as a derived demand for a recreation site that contributes to each individual's production of a recreational activity providing utility (see Deyak and Smith or Bockstael and McConnell). As a rule, the specification for these models has been largely a semantic exercise to assist in isolating the relevant arguments for a travel cost demand model.[2] We propose using this framework to describe the components of modeling decisions that may explain the variation in consumer surplus estimates across travel cost demand studies.

Consider a simple utility function specified in terms of the activities a person wants to consume, Z_i's, as in equation (1).

$$U = U(Z_1, Z_2, \ldots, Z_k) \tag{1}$$

Each Z_i is assumed to be produced by combining market goods, x_{ji}'s; time, t_i and non-marketed commodities, y_{ki}'s, as in equation (2). Of course, some activities may not use some inputs.

$$Z_i = f_i (x_{1i}, \ldots, x_{ni}, t_i, y_{1i}, \ldots y_{mi}) \tag{2}$$

where $x_{1i}, \ldots, x_{ni}$ – the amounts of the n marketed commodities used in the production of Z_i.

t_i – the amount of an individual's time used in the production of Z_i.

$$y_{11}, \ldots y_{m1} = \quad \text{the amounts of the nonmarketed commodities used in the production of } Z_1.$$

To formally derive the implications of this model for travel cost demand models we need to specify an individual's budget and time constraints to individual decisions.

With each movement away from this fairly general description of the household's choice problem, the analyst imposes more structure on the problem. This structure can arise from observing how households make decisions or from introspection. Assumptions about the constraints or features of the utility function can also focus attention on specific aspects of decision-making because these assumptions are considered to be important to the problems being addressed. Finally, in most cases, available information dictates a set of compromises that defines the structure of the model.

Developing a set of hypotheses for the factors that might influence benefit estimates from travel cost models involves consideration of five types of decisions:

(1)   specifying the types of recreation sites:

(2)   defining a recreation site, its usage, and the site quality;

(3)   modeling the opportunity cost of time:

(4)   describing the role of other sites in producing the recreation service flows;

(5)   linking the specification of the demand model to an underlying behavioral model.

We use this general specification to consider how the answers provided for each

issue affect one or more aspects of existing travel cost studies.

Describing the reasons for variation in consumer surplus estimates across sites requires us to consider the rationale for all economic models.   Most economic models assume that individuals share common behavioral functions with constant parameters, except for a set of distinguishing features (such as age or education).   This perspective implies that individuals have the same demand function for a commodity or service.   However, it recognizes that price and income differences, as well as differences in demographic characteristics, can lead to differences in the actual quantity each person will demand of any specific commodity.

In principle, the same argument applies to the measure we have used to summarize the travel cost demand estimates across studies--the consumer surplus (CS) per unit of use (v). Unfortunately, conventional theory does not offer clear guidance on the properties we might expect for this measure, given well-behaved demand functions.   This is easily seen by describing it more formally in terms of a demand function, say g (P, I, d, q), with P the travel cost, I the income, d demographic or taste variables, and q quality measures. CS/v can be defined formally by (3):

$$CS/v = L(P_o, P_c, I, d, q) = \int_{P_o}^{P_c} [g(p, I, d, q)/g(P_o, I, d, q] \, dp \quad (3)$$

where P_o - current price
P_c - choke price

The estimates of consumer surplus from the literature are generally for specific sites or derived from regional travel cost models hypothesized to describe sets of sites in the same geographic region.   To estimate CS/v requires some specification of the variables hypothesized to influence L (.).   We used the

information reported in each study to estimate the consumer surplus per unit that was representative for a typical user of the site and sample relevant to each model.

1.   Types of Recreation Sites

The first issue implies that we need a way to define the different types Of services provided by different recreation sites. Moreover, the classification cannot stop here. An individual's valuation of a site's services will depend on how these services are used. The household production framework recognizes a site demand as a derived demand.   Thus, both sources of variation must be considered. Unfortunately, our experience with such taxonomies is quite limited.

Clawson and Knetsch classified recreation sites into three categories-- user-oriented, intermediate, and resource-based. The first type of site included city and county parks, golf courses, tennis courts, swimming pools, playgrounds, etc. Intermediate sites were federal and state reservoirs and parks that provide hiking, camping, fishing, boating, and hunting. The last category had national markets because their physical characteristics were important to the recreational activities they supported. In the Clawson-Knetsch taxonomy, these attributes contributed to the fishing or hiking activities in ways that cause recreationists to perceive these activities as distinctive from the same activities undertaken in state parks.

Our specification attempts to reflect the Clawson/Knetsch perspective, but is forced by each study's site description to be fairly rough. Our classification allows a site to satisfy more than one feature simultaneously. A site with a lake may simultaneously be a state park allowing hiking and camping. We have also attempted to identify the primary activities analysts

indicated were associated with each site.   While some overlap is inevitable, the association between them is not perfect.

Equally important, these activity variables may also reflect the influence of analysts' comparative evaluations of the consumer surplus estimates. Evaluation of empirical models can involve comparing a model's consumer surplus estimates with results from the past literature to gauge their plausibility. Because most of the commonly accepted estimates of per-unit values have been for recreational activities, these variables' contribution to our models also may reflect the effects of informal screening rules for model selection. Examples of the activity-based sources for recreation value estimates include the Water Resource Council estimates of unit day values, the Sorg/Loomis review for the Forest Service RPA process, and (most recently) the Walsh et al. update of the Sorg/Loomis precis of the benefits per day of specified recreational activities.

2.   <u>What is a Recreation Site and How Do We Measure the Use of it</u>?

The early travel cost literature treated sites as well-defined entities. Because the travel cost model arose from Harold Hotelling's suggestion to consider the visitation patterns from concentric zones around a specified site, this can hardly be surprising (see also Clawson). More recently, in applications to marine recreational fishing in areas with a large array of similar sites (e.g., estuaries) or where policy requires a coordinated treatment of a large number of similar sites (e.g, the effect of acid rain on the Adirondack Lakes), the definition of what a site is has been less clear-cut. In response to the difficulties posted by developing separate site demand models under these conditions, several studies pool data across sites, arguing that their parameters were approximately constant (Sutherland [1982b]) or that site characteristics

could be explicitly incorporated into the model (Vaughan and Russell; Smith and
Desvousges [1985]).

The variables used to measure an individual's demand for a site's services
are also important in distinguishing the available models. This specification
is another example of a decision where an a priori selection of a "best" measure
is not always apparent. What is apparent, however, is that price measurement
must be coordinated with quantity measure. Some quantity measures can imply
nonlinearities in the individual's budget constraint. Defining use typically
involves two considerations--the treatment of on-site time per trip and the time
horizon for decision making.   From the perspective of a season, if y_{ki} in
equation (2) represents the use of recreation site k, we might ask if the use
of this site is to be measured as total time at the site or if trips and time-
on-site per trip should be distinguished. For many activities, the "production"
of a day of recreation is comparable to that of a longer stay. Longer trips
simply allow more of the activity (service flow) to be produced. For other
activities, this is not a reasonable assumption. Price per unit of use will
have both fixed and variable components if use-per-trip is not held constant.
Thus, the measure selected for quantity will be important to the existence of
a conventional Marshallian demand **function.**[3] On the basis of these arguments,
we define variables that describe the measurement of use (i.e., days versus
trips) and the treatment of on-site-time in the models.

3.   Opportunity Cost of Time

There are a variety of potential specifications for the constraints to
household utility maximization--technology, income, and time constraints, The
full income concept, following Becker's original usage, links time and monetary

constraints by defining income in terms of earnings and other sources of income, Time is assumed to be freely substituted in any use, so all uses of time have the same opportunity costs (the wage rate). Alternatively, we might specify different opportunity costs, using the wage rates for part-time work (see Bockstael, Strand, and Hanemann). Yet another possibility specifies different time constraints and maintains that not all types of time can be substituted (see Smith, Desvousges, and McGivney).

Each formulation will have quite different implications for the implicit price estimated for the use of a recreation site. In this example, use corresponds to one trip to the site. In general, an individual's implicit price, k, to use a recreation site for a fixed amount of time would be defined as:

$$k = cd_\ell + \lambda\phi_\ell \tag{4}$$

where: d_ℓ - round trip distance to site ℓ.

c - vehicle operating cost per mile

ϕ_ℓ - travel time for one round-trip to site ℓ

λ - shadow price for travel time

This implicit price would vary by the location of the individual and, potentially, by whether vehicle costs were shared. In the full income model, λ is the wage; the Cesario/Knetsch proposal treats it as a fixed fraction of the wage; the Bockstael et al. framework maintains that λ will depend on the definition of the marginal time unit for each person and by the degree of control he (or she) has over time allocations. In the different "types of time" model, λ becomes a nonlinear function of the wage rate and other parameters of the individual's decision process.

With detailed information on the time constraints, wage rates, and job opportunities for individuals, it would be possible to test these models. Unfortunately, the available information generally falls short of implementing any of these frameworks. In fact, the early models based on origin zone data preclude serious consideration of any of these approaches. Consequently, the literature offers a selection of approximations. Because wage rates are often unknown, they must be estimated.

The time horizon relevant for decision making is itself an issue. This has become especially relevant to comparisons of recreation models developed using a random utility framework. In several cases, these models seek to explain decisions on single trips, as if each decision was independent of what has happened earlier. This formulation implicitly compresses the time horizon underlying a model of individual choice, because in most instances it describes the problem from a single-trip perspective. Opportunity costs must be treated differently in this context, because the choices for time uses may be more limited with this compressed decision horizon.

Our measures of site usage and individual time allocation decisions are exceptionally limited. Because of these limitations, analysts have usually proposed informal rules, such as maintaining that opportunity costs are between one-fourth and one-half the level of the wage rate (Cesario and Knetsch). Our analysis defines variables that describe how past studies measured the wage rate and how they described the opportunity cost of travel time.

4.   The Treatment of Substitute Sites

On theoretical grounds, we have little to debate about the relevance of substitute prices for modeling the demand for any commodity, including

recreation sites. However, this is not the issue that must be addressed in implementing a travel cost recreation demand model. As a rule, micro level surveys include information on the respondents' judgments about their "next best alternative."[4] Thus, in practice, the issue of including substitute prices is not clear-cut.[5] It requires determining what sites are actually available and how potential users perceive alternative sites. As Rosenthal [1987] observed, collinearity between price measures can yield the appearance of a small role for substitute prices.[6] For the most part, past efforts can be grouped into three alternatives: (a) excluding any consideration of substitutes (and this has been the majority of the work); (b) formulating arbitrary indexes of existence of substitutes using a diverse array of specifications (each with little connection to micro theory); and (c) including a selection of substitute prices. Based on this diversity in practice, we have defined a variable to reflect the treatment of substitutes.

5. The Behavioral Framework and the Empirical Model

The specification of any estimating model introduces implicit restrictions that affect how any sample of actual choices is described. Economists working with recreation demand modeling are beginning to question how these implicit restrictions should be selected. For example, Kealy and Bishop, Bockstael, Hanemann, and Strand, and other authors argue that these specifications should follow from a well-defined behavioral model, based on a specific functional specification for either the direct or the indirect utility function. From these authors' perspectives the "leap of faith" that often separates the theory and empirical sections of applied papers is inappropriate. A contrasting view of the process might suggest that because our information is incomplete, we have

no reason to believe a complete behavioral description will be better than starting with a "reduced-form" approximation.

An examination of the results from existing studies cannot answer this question, because we do not know the truth. Nonetheless, by examining the influence of the demand specification for the consumer surplus estimates, we can determine whether an answer is important. To examine the importance of these types of judgments, we grouped the variables used to describe each set of estimates into two classes--one set reflecting different (but economically plausible) maintained hypotheses and a second describing analyst decisions where either the economic theory does not provide guidance or limitations in the available data require assumptions. By testing whether the second set provides significant determinants of the consumer surplus estimates, we can gauge the importance of these more arbitrary modeling decisions.

III. Results

Our analysis is based on a review of published articles in a wide array of journals that included travel cost demand models, government reports, and unpublished papers, as well as Masters and Ph.D. theses from 1970-1986. We identified the studies by surveying all issues of the relevant journals; by contacting economists who have developed travel cost demand models, government agencies (e.g., the Fish and Wildlife Service, Office of Policy Analysis in the Department of Interior, Forest Service Regional Offices and others) and the chairpersons of departments of agricultural economics and economics for unpublished papers and graduate student Masters and Ph.D. essays; and by reviewing the University of Michigan microfilm listings for the abstracted Ph.D. dissertations in resource economics. We have attempted to exclude double entries

for unpublished Ph.D. theses and subsequently published articles.

We have reviewed approximately 200 studies to determine if they had empirical estimates for travel cost recreation demand models and provided sufficient information to estimate the Marshallian consumer surplus per unit of use. The results reported here relate to 77 studies with either benefit estimates or sufficient information to derive them. The Appendix lists the studies and the range of consumer surplus estimates in real terms for those with sufficient information to be included in our final empirical models (columns 6, 7, and 8 in Table 2). Using all 77 studies, there are 734 observations for our analysis. However, as we discuss further below, there is not complete information on all variables. Several studies are responsible for multiple observations because they reported results that varied: the demand models' functional form; the maintained assumptions; estimators; and definition for the recreation sites. Consequently, our sample resembles a panel data set and this feature must be reflected in how we analyze these data.

Our empirical model hypothesizes that the variation in benefit estimates arises from the theory underlying these demand analyses together with the practical issues that we identified earlier to be addressed in implementing it. The variables used to explain the estimates of benefits can be classified according to features implied by: the assumptions inherent in the behavioral model underlying the travel cost framework, including the definitions for the measures for quantity and own price, as well as the treatment of substitutes (designated here by a vector of variables, X_a); the specifications used for the estimated demand function (designated by a vector of variables, X_b); and the econometric estimator used for the model (designated by a vector, X_c).

Equation (3) above defined consumer surplus per unit of use for a given

recreation site. In formulating hypotheses concerning the effects of each class of variables on estimates of CS/v across studies, it is important to recognize that the features of each recreation site (X_s) and the recreational activities undertaken (X_A) should influence the true value for consumer surplus per unit. Moreover, differences in the assumptions made for the variables in L(.) across studies will contribute to variations in estimates of CS/v. Assuming differences in these specifications for other economic and demographic variables are not important, the true surplus might be hypothesized to be a function of variations in X_s and X_A as in equation (5) below. The only specification for the demand function which satisfies this condition is the semi-log form. If b designates the absolute value of the price coefficient, then 1/b is often used as a measure of the Marshallian consumer surplus per unit of use (i.e. depending on how the quantity variable for the model is defined).'

To the extent economic and demographic assumptions are greatly different for the same type of site across studies, then we would expect α_0 to vary with them. Equation (5) assumes that each type of site and primary activity can be classified into the categories identified by the sets of variables included in X_s and X_A, with the subscript i used to designate each estimate.

$$(CS/v)_{Ti} = \alpha_0 + \alpha_s X_{si} + \alpha_A X_{Ai} \tag{5}$$

$(CS/v)_T$ is measured per unit of use to reflect differences in the conditions of access across studies. This formulation implicitly assumes the average consumer Surplus per unit of use should be comparable (for the same types of resources, uses, and individuals) when the conditions of access are comparable.

Estimates of $(CS/v)_T$ will be functions of demand parameter estimates, as

well as the variables determining individual demand.   Because these estimated

parameters can be shown to be functions of the true values of the parameters,

it is reasonable to hypothesize that the estimated consumer surplus per unit of

use, $(CS/v)_E$ is some function of $(CS/v)_T$. Our proposal for summarizing empirical

work implicitly- maintains that there are more factors involved--the variables

describing each study's maintained behavioral assumptions (X_S), as well as each

analyst's judgments $(X_O$ and $X_E)$. Equation (6) hypothesizes that these effects

are additive influences to the true value and therefore would be reflected in

the bias in any estimator for $(CS/v)_T$. Linearity is a simplification.

Equation (6) has no intercept because we hypothesize that there is no fixed

bias, independent of the modeling assumptions, in the estimates for consumer

surplus per unit.   The fixed bias will depend on the model used.   Of course,

variables may well be omitted, but these are more likely reflected in the error

term, ϵ_i, because they can be expected to vary with each study.

$$(CS/v)_{Ei} = \beta(CS/v)_{Ti} + \gamma Z_i + \epsilon_i \tag{6}$$

where Z_i - a vector of variables describing modeling decisions
(i.e, $Z_i = (X_{Si}\ X_{Oi}\ X_{Ei})$ with γ a conformably dimensioned vector of parameters

ϵ_i - stochastic error

Substituting (5) into (6) we have the basic form of our estimating model in

equation (7).

$$(CS/v)_{Ei} = \beta\alpha_0 + \beta\alpha_S X_{Si} + \beta\alpha_A X_{Ai} + \gamma Z_i + \epsilon_i \tag{7}$$

Under ideal conditions β would be unity.

An important byproduct of an attempt to model the results of applied economic research is the development of hypotheses for the components of z_i. This process requires reconsidering the logical structure that we assume describes the development of economic models. While some progress has been made in macro-economic, time-series applications (see Hendry), few findings are available to use for applications to environmental resources. Thus, our discussion will be an informal first-step toward the more comprehensive efforts required if we are to use meta-analysis in evaluating and improving applied economic methodologies.

Following Hendry, if we regard any economic model as a strategy determined by the problem at hand and the information available, then we can be reasonably confident that some elements of modeling decisions (such as the treatment of substitutes or the specification of the opportunity cost of time) should play a role in the "true" demand function for a recreation site. But we cannot specify in advance which of the available assumptions is correct. Moreover, we may expect this judgment to change depending on the application. Thus, we can distinguish studies that fail to recognize these factors from those that do, but we cannot specify a best strategy for each case.

In applications of meta-analysis in other disciplines, these judgments are used to develop quality weights. These weights are applied to the results from each study as part of the development of the statistical aggregate, We have not used this approach in our econometric analysis for two reasons. First, and most importantly, the correct treatment of these modeling judgments in a statistical summary depends on whether we believe they affect the bias or variance in the estimates. Weighting implicitly assumes that the estimates based on incorrect modeling judgments remain unbiased but simply have less informational content

(i.e. have higher variance). Chile this may well be appropriate for summaries of studies involving primarily controlled experiments, it does not seem as clear-cut for economic applications.

Second, because several decisions can be identified as reflections of specific maintained hypotheses in each study, weights for each (even if the first issue favored weighting) require a set of subweights for each of these decisions. We do not feel this is possible given our current level of understanding of how people make recreation decisions. Indeed, our empirical analysis provides the first evidence on how influential these judgments are for the existing estimates.

With this background, we can distinguish variables that are largely data-based decisions where there is little guidance available in economic theory (those in X_0 and X_ℓ) from those that are based on theory (X_a). By testing the influence of the former on our statistical summaries, we can provide some direct evidence on the role of these types of decisions on the existing estimates. From the perspective of transferring model results, we would prefer that these types of decisions had a small role in explaining the (CS/v) estimates for comparable recreation sites.

Table 1 defines the specific variables used in our analysis. $(CS/v)_{\ell i}$ is measured by the real (constant dollar) consumer surplus per unit of use. As one would likely expect, most of our variables are qualitative. Because $(CS/v)_{\ell i}$ is derived from empirical models based on quite different data sets and precision in estimating the parameters relevant to the estimation of the consumer surplus, it is reasonable to expect heteroskedasticity. Indeed, as Bockstael and Strand observed, it should be possible to estimate the variances in these estimates for the consumer surplus. There are two potential problems with implementing this approach. First, the information routinely reported in travel cost demand

studies is generally not sufficient to construct approximate estimates of the variances for the (CS/v) estimates. Second, and equally important, recent sampling experiments and bootstrap calculations indicate the approximations used in constructing these estimates can themselves be subject to important errors (see Smith [1989] and Kling and Sexton).

The panel nature of our data set introduces another source of non-spherical errors. If, for example, we assume a simple random effects model, then autocorrelation will be present. In this case, it arises because there is a common error shared by results from different models reported within the same study. In principle, we might also want to distinguish (in the formulation used for the error process) whether the different estimates reported for each study reflected different modeling assumptions for the same site, the same basic model applied to different recreation sites, or some combination of these effects, as might be present in the regional travel cost models.

An estimator that accounts for the composite effects of all of these factors would require imposing considerable prior information to estimate the relevant variances and covariances for the estimates of $(CS/v)_{\ell i}$ across studies. To avoid imposition of largely arbitrary assumptions, we have adopted an alternative strategy--estimate equation (7) with ordinary least squares (OLS), but report the Newey-West version of the White consistent covariance estimator for OLS in the presence of heteroskedasticity and a generalized form of autocorrelation.[*] As the results in Table 2 indicate, our basic conclusions are largely unaffected by the standard errors used in tests of the effects of individual variables.

Table 2 reports our estimates for several alternative models describing the factors influencing the real consumer surplus. The numbers in parentheses below the estimated coefficients are the t-ratios calculated with the OLS

standard errors, while those in brackets are the t-ratios using the standard errors from the adapted White consistent covariance matrix. Eight models are reported to illustrate different aspects of our summary. The first three ignore the role of recreation activities and focus exclusively on either assumptions variables (column (1)) or the variables describing the type of site (column (2)) or both (column (3)). Column (4) expands the analysis in column (2) to include the primary recreational activities supported by the site. Columns (3) and (5) treat the definition of site type and primary recreational activities as alternative proxies for the same effects, and include one of the two sets with the other variables describing the modeling strategies. Columns (6) and (7) report our most detailed model (6) and the same model omitting only the variables describing assumptions derived largely from data-based judgments. The last column offers an alternative to our most detailed model, deleting the variable for the year of the data used in the study.

The variable "Year" was considered to evaluate an interesting suggestion made by an anonymous reviewer of an earlier version of this paper. This reviewer suggested that we might be able to investigate whether recreational resources were growing more or less scarce by including this type of variable. Under ideal conditions, this is an intriguing possibility. However, we believe this variable serves primarily as a proxy variable for the composite of changes in the types of data, estimators, and methodological advances that have taken place over the time period spanned by our review. These factors cannot be distinguished from the relative value (comparable to a relative price) one would like to evaluate for the scarcity issue. We report as "final" models equations that include all types of effects with and without the year variable. However, we believe that column (8) is probably a better overall description (despite

the statistical significance of year) because of the consistency in the parameter estimates with other less complete models and the quite consistent pattern of change in the variables describing each study's characteristics when year is included.

Our results have implications for three types of questions. First, because the studies we reviewed span a period during which the conceptual models, data sets, and estimators for recreation demand analysis improved, we can evaluate the implications of a wide range of modeling judgments for consumer surplus (i.e. CS/v) estimates.   Second, the studies considered also include an array of different types of recreation sites. This permits an evaluation for the relative importance of the type of site for these estimates.   Finally, they have implications for the feasibility of using econometric reviews of the empirical benefits literature in the task associated with benefits transfer for policy evaluations.

It is important to recognize at the outset that the feasibility of using econometric methods in literature reviews would be greatly enhanced with a change in reporting conventions for empirical results.   These conventions are so variable across studies that the set of available estimates with a detailed set of explanatory variables is almost half the size of our full sample of estimates. Because missing values for particular classes of variables changed our sample composition dramatically, we investigated their   effects by considering alternative subsets of the potential explanatory variables specified to influence (CS/v). This process explains the rationale for the first five columns in Table 2.   The estimated effects of the variables describing the modeling Strategies are quite stable across models in terms of their signs and statistical significance. Virtually all the decisions on the assumptions associated with

modeling strategies that we describe with qualitative variables were statistically significant factors in determining the real consumer surplus (CS/v) estimates.

When the variables are interpreted in terms of the classification we proposed in developing equation (7), the key economic assumptions (such as the inclusion of a substitute price or measure of the implicit costs of travel time) are generally significant determinants of the estimate for the (CS/v) and conform with _a priori_ expectations. The adjustment for the measure of use indicates, as we would expect, smaller benefits per unit in terms of days versus trips. The parameter restrictions implicit in the use of a regional travel cost model appear to increase estimates of (CS/v). This finding is more difficult to relate to economic theory. The restrictions imposed by the regional travel cost model have implications for the implicit extent of a recreation market; for whether sites are considered equivalent (by recreationists) in terms of the estimated demand responses to own price and income; and for the definition for what constitutes substitute sites.

Some modeling judgments are based on each application's data and do not have a rationale in economic theory. We have classified the variables describing the functional form and estimator in this category. While one might argue that the estimator follows from prior information on the sampling process, we believe the potential sensitivity of estimates to parameterization for the error structure or its distribution often leads analysts to an implicit pretesting process. In these cases, results from different estimates are compared as part of the development of the "final" reported results. Because we have adopted this view of the process, we have included the estimator in the data-based variables.

One way of evaluating the sensitivity of estimates to data specific

judgments is to test the null hypothesis that the variables associated with these decisions do not exert a significant influence on (CS/v). The results in columns (6) and (7) indicate that this hypothesis is decisively rejected at the one percent significance level.

The use of a maximum likelihood estimator and selection of a log-linear demand specification seem especially important individual choices. The sensitivity of results in each case may reflect biases arising in other studies that do not make these assumptions. This may be especially true for the use of procedures adjusting for the on-site, intercept nature of most micro level recreation surveys. Nonetheless, the importance of both decisions for estimates could be reduced with improved information on the nature of households' recreation site choices, including the amount of use and the time and resource constraints underlying these decisions.

We are able to distinguish separate effects for our measures of the type of recreation site and for the primary activities supported by a site. Because the site definitions are not mutually exclusive categories, we need to interpret the results carefully. For example, a trip to a lake in a national park would be worth $19.94 more than one of comparable length to a coastal area (i.e., the sum of the coefficient for National Park, 41.13, and that of Lake, -21.19 in column (8) of Table 2). The results indicate that sites supporting wilderness activities do not appear different than those for developed camping, comparing their consumer surplus estimates. This seems implausible, given the activities involved, and is likely to result from the small number of travel cost estimates for wilderness areas (i.e. about 10 of the 399 used in the models).

Finally, this type of model offers the potential for "checking" the benefit transfer estimates developed in policy analysis. Because we do not have a

theoretical basis for specifying how (CS/v) should behave across different types of recreation sites and modeling strategies, it would not be prudent to recommend this type of model for predictions of consumer surplus per unit of use. Intangible dimensions of a research study exist which are difficult to encode in the quantitative terms required for an econometric summary. These factors may well be important to how policy analysts should use a particular study in a benefits transfer. At this stage, we can say that these types of empirical summaries can serve as a consistency check on the processes used in policy analyses to gauge the implications of selecting a different set of assumptions. They also offer a first step in a more general question--how do we want to summarize the results of applied demand analysis? Should the focus be on the consumer surplus per unit of use or the own-price elasticity of demand? Either could be used (with supplementary assumptions) as a basis for evaluating policy uses of benefit studies on the research shelf.

IV.   Implications

As the literature reporting benefit estimates for environmental resources expands, the task of summarizing what we know and how to use it in evaluating new policies that affect environmental and other resources becomes more difficult. Our findings here indicate that econometric methods can be wed to summarize the results from diverse empirical studies. Indeed, in our specific application (travel cost recreation demand models), this approach provided clear support for the issues identified in the theoretical and recent empirical literature as central to implementing the model. They include:

   (a)   the implications of the treatment of an individual's time constraints
          for his (or her) opportunity costs of time (see Bockstael, Strand,
          and Hanemann);

(b) the identification and treatment of substitute sites in modeling recreation demand (see Rosenthal);

and

(c) the adjustment of estimates from on-site micro data sets for the specification effects of these sampling procedures (see Shaw).

These factors are important from a conceptual perspective, and they could help to resolve the rather wide variation in real consumer surplus across studies.

More generally, these results offer some confirmation that systematic factors influence the disparity in results across studies. However, applied econometric analyses of recreation demand require substantial discretionary judgments to overcome limitations imposed by data and by our knowledge of economic agents' behavior. Some of these factors arise from differences in the resources involved and others from the assumptions used in these studies. Because it appears possible to separate the influence of these factors, reviews of empirical research using econometric methods to estimate these types of response surfaces based on the empirical findings can also have important policy applications. They offer a method for bounding (or for checking) the estimates derived for new or improved resources. They can serve to identify the factors leading to the greatest disparity in benefit estimates. And, finally, these cross-study empirical summaries may also help to isolate the areas requiring further research.

Table 1. DESCRIPTION OF VARIABLES FOR ANALYSIS

Name	Mean	Definition of Variables
(CS/v)	25.24	Marshallian consumer surplus estimated per unit of use, as measured by each study (i.e., per day or per trip) deflated by consumer price index (base - 1967)
SURTYPE	.86	Qualitative variable for measure of site use - 1 for per trip measure, 0 for per day measure
Type of Recreation Activities	---	Water-based recreation (swimming, boating, fishing), hunting, wilderness hiking, and developed camping were identified as the primary activities. The first three are introduced as qualitative variables with developed camping as the omitted category.
Type of Recreation Site	...	Lake, river, coastal area and wetlands, forest or mountain area, developed or state park, national park with or without wilderness significance are the designations. Coastal area and wetlands was the omitted category. Variables are unity if satisfying designation, zero otherwise.
Substitute Price	.29	Qualitative Variable - 1 if substitute price term was included in the demand specification, 0 otherwise
Opportunity Cost type #1	.24	Qualitative Variable for the measure used to estimate opportunity cost of travel time - 1 if an average wage rate was used.
Opportunity Cost type #2	.32	Qualitative Variable for the second type of opportunity costs of travel time measure, - 1 for use of income per hour: the omitted category was the use of a projection for an individual specific wage rates.
Fraction of wage	.37	Fraction of wage rate used to estimate opportunity cost of travel time
Specific Site	.24	Qualitative Variable for use of a state or regional travel cost model describing demand for a set of sites - 1, 0 otherwise.
Demand Specifications	---	Linear, log-linear and semi-log (dep) are qualitative variables describing the specification of functional form for demand (semi-log in logs of independent variables was the omitted category).
Year	---	The year of the data used in each study.
Estimators Used[a]	---	OLS, GLS, and ML-TRUNC are qualitative variables for estimators used, omitted categories correspond to estimators with limited representation in studies--the simultaneous equation estimators.

[a]ML-TRUNC refers to maximum likelihood estimators adjusting for truncation and tobit estimators. GLS includes both single equation generalized least squares and seemingly unrelated regressions.

Table 2. DETERMINANTS OF REAL CONSUMER SURPLUS PER UNIT OF USE[a]

Independent Variables	Models							
	1	2	3	4	5	6	7	8
Intercept	20.30 (6.19) [3.92]	27.03 (3.68) [3.64]	18.75 (0.58) [1.04]	23.48 (1.57) [3.71]	-.30 (-.01) [-0.011	5174.24 (3.95) [3.39]	4904.00 (3.75) [3.52]	-25.20 (-0.57) [-1.74]
SURTYPE	-9.97 (-2.72) [-1.361	15.38 (2.97) [2.34]	19.88 (3.74) [3.55]		1.03 (0.23) [0.12]	28.75 (4.84) [4.71]	16.94 (2.78) [2.05]	19.18 (3.46) [3.10]
(X_A) Type of Recreation								
Water-Based Activities				14.50 (0.83) [1.08]	24.50 (1.97) [2.72]	24.43 (0.78) [1.95]	-9.07 (-0.26) [-0.96]	45.39 (1.44) [4.01]
Hunting				17.35 (1.33) [4.23]	20.02 (1.53) [1.63]	-2.33 (-0.18) [-0.26]	-1.10 (-0.08) [-0.14]	13.78 (1.07) [1.46]
Wilderness				-12.10 (-0.66) [-2.49]	10.92 (0.76) [0.62]	-26.57 (-1.47) [-1.95]	-17.52 (-0.91) [-1.47]	.60 (0.04) [0.07]
(X_S) Type of Site								
Lake		-18.69 (-3.24) I-2.36]	-20.32 (-3.52) [-2,48]	-17.47 (-3.12) [-2.281		-22.16 (-3.88) [-2.57]	-13.21 (-2.42) [-1.601	-21.19 (-3.65) [-2.55]
River		-14.29 (-2.99) [-1.95]	-19.03 (-2.19) [-1.75]	-12.19 (-2.57) [-1.86)		-16.44 (-1.91) [-1-60]	3.23 (0.44) [0.32]	-19.80 (-2.27) [-1.80]
Forest		-18.45 (-2.36) [-1.93]	-25.99 (-3.01) [-2.49]	-15.37 (-1.31) [-2.53]		-1.36 (-0.05) [-0.16]	-20.74 (-0.64) [-2.25]	6.84 (0.23) [0.82]
State Park		24.95 (3.47) [3.27]	22.37 (3.44) [3.19]	14.10 (2.40) [1.64]		28.39 (4.28) [3.30]	24.46 (3.44) [3.07]	22.18 (3.37) [3.20]
National Park		.56 (0.04) [0.08]	-3.77 (-0.23) [-0.13]	30.71 (2.16) [2.51]		49.37 (1.33) [1.58]	-5.43 (-0.14) [-0.25]	41.13 (1.09) [1.24]

Table 2 (continued)

Independent Variables	Models							
	1	2	3	4	5	6	7	a

(X$_a$) Model Assumption

	1	2	3	4	5	6	7	a
Substitute Price	-18.73 (-3.27) [-4.58]		-13.71 (-2.12) [-1.80]		-23.80 (-3.76) [-3.18]	-11.42 (-1.82) [-1.43]	-18.58 (-3.00) [-4.10]	-14.39 (-2.26) [-1.80]
Opportunity Cost Type #1	-14.97 (-2.10) [-2.09]		-16.49 (-2.11) [-2.48]		-21.68 (-2.94) (-2.721	-6.03 (-0.73) [-0.71]	8.03 (0.97) [0.95]	-14.28 (-1.75) [-1.98]
Opportunity Cost Type #2	3.95 (1.02) [0.45]		-15.86 (-3.30) [-2.87]		-13.59 (-2.75) [-1.93]	-10.97 (-2.22) [-1.90]	5.84 (1.39) [0.71]	-15.89 (-3.26) [-2.80]
Fraction of Wage	37.24 (8.56) [3.83]		48.59 (9.76) [6.94]		55.88 (11.41) [7.33]	45.10 (9.09) [6.70]	27.02 (6.01) [2.54]	48.59 (9.76) [6.91]
Specific Site/ Regional TC Model	22.23 (4.10) [3.35]		24.21 (3.85) [2.77]		21.75 (3.54) [2.08]	16.49 (2.55) [1.62]		23.54 (3.71) [2.64]

(X$_D$) Model Specification

	1	2	3	4	5	6	7	a
Linear			-2.87 (-0.27) [-0.31]		12.99 (1.19) [1.10]	-15.33 (-1.37) [-1.41]		-2.94 (-0.27) [-0.29]
Log-Linear			23.37 (2.37) [2.88]		28.57 (2.67) [2.05]	15.61 (1.37) [1.59]		24.65 (2.36) [2.68]
Semi-Log (Dep)			16.89 (1.86) [2.97]		15.97 (1.62) [2.07]	9.29 (0.97) [1.74]		18.61 (1.96) [2.86]

(X$_E$) Estimator:

	1	2	3	4	5	6	7	a
OLS			-14.45 (-0.48) [-0.84]		-24.20 (-0.76) [-1.39]	-28.96 (-0.96) [-1.39]		-16.21 (-0.53) [-0.921
GLS			-8.58 (-0.28) [-0.54]		-24.77 (-0.78) (-1.531	-21.88 (-0.73) [-1.13]		-8.58 (-0.28) [-0.53]

Table 2   (continued)

Independent Variables	Models							
	1	2	3	4	5	6	7	8
ML-Trunc			-67.38 (-2.15) [-3.43]		-77.35 (-2.38) [-3.65]	-85.06 (-2.74) [-3.63]		-68.98 (-2.20) [-3.46]
Year						-2.61 (-3.98) [-3.63]	-2.47 (-3.74) [-3.52]	
R^2	.25	.15	.42	.15	.36	.45	.30	.43
n	399	399	399	405	405	399	399	399

[a]The numbers in parentheses below the estimated parameters are the ratios of the coefficients to their estimated standard errors.   The numbers in brackets use the Newey-West variant of the White consistent covariance estimates for the standard errors in calculating these ratios.

1.   Hedges and Olkin credit Glass with the first use of meta-analysis in educational and psychological research. There are important differences in the use of these methods for applications in these disciplines, as well as for medical research, in comparison with economics. All of the former have involved controlled experiments, where the statistical analysis can be treated as aggregating independent observations from each study's sample of experimental findings (see Cordray).

2.   Bockstael and McConnell [1983] is a notable exception to this work, because they use the formal structure of a household production framework to describe the measure of the demand for non-marketed commodities and the role of the assumption of weak complementarily.

3.   This problem is analogous to the issues raised in modeling the demand for electricity in the presence of declining block rates (see Taylor [1975] for an early discussion) or in the more recent analyses of hedonic models' ability to recover estimates of the willingness-to-pay functions for non-marketed resources. See Bartik and Smith [1987].

4.   These types of questions can be found on the recent Public Area Recreation Visitors Surveys conducted by the U.S. Forest Service, as well as on a wide variety of other micro-level site-specific surreys. This framework presumably arises because of the difficulty of encoding (with an on-site survey) a consistent set of substitute sites.   See Smith and Desvousges [1986] for discussion of a procedure used in surveying water-based recreation participation pattern as part of a contigent valuation survey.

5.   Hof and King [1982] give the impression that the issues are clear-cut. In practice, data inadequacies and on-site surveys make the process of inferring the feasible set of substitutes and of treating them consistently exceptionally difficult.

6. Collinearity in the cross price measures makes it difficult to precisely estimate their effects on demand. It does not affect the magnitude of the estimated coefficients. However, to the extent these are not estimated at conventional standards for statistical significance, practitioners can easily be faced with a dilemma in judging how to interpret and respond to test results in these cases.

7. While this estimator for (CS/v) has been commonly used in the literature, without a consistency check to screen for negative values, it will not have finite moments (see Smith [1989]).

8. A lag of eleven periods was used in implementing the Newey-West version of White's estimator.

APPENDIX

Real Consumer Surplus per Unit of Use and own Price Elasticity of Demand[a]

Author	Identification Number	Number of Estimates	Range (Estimate)	
			(CS/v)	Own Price Elasticity
Karl C. Samples and Richard Bishop	1	11	.11 - 6.24	---
Marc O. Ribaudo and Donald J. Epp	2	1	3.66	-.49
Donald H. Rosenthal [1985]	4	22	.46 - 5.85	-1.79 to -4.58
Christine Sellar	5	11	2.89 - 15.17	-0.003 to -0.02
Cindy F. Sorg, John B. Loomis, D. Donnelly, G. Peterson, L. Nelson	13	51	9.19 - 20.81	---
Abraham E. Haspel and F. Reed Johnson	17	6	20.60 - 36.84	---
Fredric C. Menz and Donald P. Wilton	22	5	9.02 - 20.60	-1.49
John K. Mullen and Fredric C. Menz	23	3	7.41 - 13.12	---
William G. Brown, Colin Sorbus, Bih-lian Chou-Yang, and Jack Richards	25	1	15.93	---
J. A. Sinden	34	1	.29	-.54
R. E. Capel and R. K. Pandey	37	1	9.26	-1.05
Ronald J. Sutherland (1982a)	45	40	1.36 - 40.32	---
V. Kerry Smith and William H. Desvousges (1985)	51	44	1.97 - 219.78	-.04 to -2.99
V. Kerry Smith, William H. Desvousges, and Ann Fisher	52	1	7.21	---
John B. Loomis (1986a)	62	1	12.53	---
John B. Loomis (1986b)	63	3	11.53 - 22.36	-1.63 to -1.71
W. David Klemperer, Gregory J. Buhyoff, P. Verbyla, and L. Joyner	67	8	.92 - 3.90	---

Appendix (continued)

Author	Identification Number	Number of Estimates	Range (Estimate) (CS/v)	Own Price Elasticity
Cindy F. Sorg and Louis J. Nelson	71	2	21.20 - 33.50	•••
Cindy F. Sorg, John B. Loomis, D. Donnelly, G. Peterson, L. Nelson	72	4	13.23 - 14.41	•••
Dennis M. Donnelly, John B. Loomis, Cindy F. Sorg and Louis Nelson	73	2	6.67 - 9.35	---
Stephen Farber	79	1	17.45	•••
Werner J. Sublette and William E. Martin	82	4	7.88 - 37.54	•••
William J. Vaughan and Clifford S. Russell	84	4	3.23 - 7.88	•••
Thomas Gifford Sawyer	96	1	48.11	-.17
C. Tim Osborn	97	1	88.07	-.27
Trellis G. Green	98	2	59.96 - 146.95	-.0016 to -.005
Daniel Wayne McCollum	99	28	8.06 - 146.95	•••
Colin Norman Sorhus	103	4	9.23 - 28.47	-.73 to -.81
Faisal Moftah Shalloof	105	8	49.14 - 91.59	•••
Bahram Adrangi	109	2	7.68 - 10.02	---
Steven Eric Daniels	112	5	4.99 - 6.23	-5.97 to - 6.96
Chung-Huang Huang	113	43	4.93 - 60.20	-.05 to -.84
Margaret Tambunan	114	73	4.77 - 327.22	-.0003 to -.93
V. Kerry Smith and Raymond Kopp	115	2	4.22 - 11.84	-1.59 to -1.71
V. Kerry Smith (1975)	116	2	5.03	•••

[a]These results are for only those studies included in our most detailed model based on 399 estimates from 35 studies.

CHAPTER 2

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CHAPTER 3

WHAT HAVE WE LEARNED SINCE HOTELLING'S LETTER?

A META ANALYSIS

V. Kerry Smith
and
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What Have We Learned Since Hotelling's Letter?

A Meta Analysis

V. Kerry Smith and Yoshiaki Kaoru

I. Introduction

In 1947, Harold Hotelling proposed the first indirect method for measuring the demand for a non-marketed commodity. His letter, responding to a request by the director of the National Park Service for methods that might be used to measure recreation benefits, introduced the travel cost recreation demand method[1]. About twelve years later, Trice and Wood [1958] and Clawson [1959] independently implemented the methodology. Because there have been hundreds of applications in the intervening thirty years, a comprehensive literature review could easily fill several lengthy papers[2]. Moreover, given the diversity of recreation sites and types of data, the task of developing a consistent synthesis is exceptionally difficult.

This paper proposes the use of econometric methods for quantitative reviews of empirical literature. Our strategy builds on the concept of statistical review or meta-analyses introduced into the education and psychology literature by Glass [1976] (see also Hedges and Olkin [1985] and Cordray [1987] for detailed discussion). Because empirical studies in economics are rarely controlled experiments, the data aggregation methods proposed for most meta analyses must be replaced by the multivariate methods routinely applied in econometric analysis. This paper uses the travel cost recreation demand literature to illustrate what can be learned from a meta-analytic review.

II. Data, Model and Results

The data for this meta-analysis of travel cost recreation demand models were derived from a larger study investigating the feasibility of transferring

recreation benefit estimates from the situations where they were estimated to new applications of policy interest (see Smith and Kaoru [1989]). As part of that effort, we reviewed 200 published and unpublished studies of the demand for recreation resources prepared from 1970 to 1986. The set of studies considered was developed by: (1) reviewing all journals (both economic and noneconomic) that consistently publish recreation demand studies; several computer literature searches and dissertation abstracts; and by contacting active researchers in this area, chairpersons for all economics and agricultural economics departments with graduate programs in the U.S., and the research experiment stations of the U.S. Forest Service.

Seventy-seven of these studies reported sufficient information to permit estimation of the benefits provided by the site(s) involved in each study. They represent the initial data base for this study. Forty-seven were unpublished (Master's and Ph.D. theses and papers or reports) and 30 **published**[3]. Seventy-nine percent of the studies were prepared in 1980 or later. Thirty-one studies reported sufficient information to estimate the own price elasticity of demand implied by each demand model. Our analysis was confined to the studies whose models yielded theoretically plausible elasticity estimates (i.e., negative values). Overall, these studies lead to 211 own-price elasticity **estimates**[4]; 88 percent of these cases also had sufficient detail to permit a meta analysis of the determinants of the estimated price elasticities.

Our analysis is based on a simplified view of model development adapted from Hendry's [1983] work in the context of macro models. The arguments we hypothesize to be the important determinants of the quantity demanded of a normal good or service are reasonably well-defined from theory (i.e., prices, income,

and perhaps variables reflecting individual tastes). The empirical implementations of these models depend on the problem(s) being addressed and the data available. For the most part, inadequacies in data introduce a large number of compromises. Our specific application is important to these compromises,

The essential element in Hotelling's proposal was the recognition that people pay an implicit price for the use of a recreation site. This cost is the total of the travel-related costs to visit the site, including both the vehicle-related and time costs. The pricing of the time costs has been an important research focus of the literature. Equally important, the definition of substitutes for a particular recreation site and the measurement of how a site is used are also important distinguishing features of past studies. The type of data available affects the estimator used and has been important to the diversity of estimates in recent applications. Theory does not offer guidance on the functional form or definition of what constitutes homogeneous services from one (or more) recreation site(s). In addition to these practical modeling decisions, we would expect that demands for different types of sites would be different[5].

On the basis of these types of arguments, we might hypothesize that estimates of the demand parameter of interest, y, would be a function of: what is demanded (i.e., the type of site) X_1; how the economic arguments are defined and measured X_2; and potentially some of the details of implementation X_3, as in (1)

$$y_i = \alpha_0 + \alpha_1 X_{1i} + \alpha_2 X_{2i} + \alpha_3 X_{3i} + \epsilon_i \qquad (1)$$

The X's will be vectors of variables reflecting these influences and ϵ_i is the

error, reflecting omissions, modeling mistakes and the approximate nature of equation (1).

The composition of X_1, X_2, and X_3 will depend on what we designate as y. Because the own-price elasticity of demand is usually a key motivation for developing demand estimates, it seems a natural choice for y. However, it need not be the only one. One important by-product of this process of developing these types of empirical summaries is the identification of this issue. It is quite possible that different model features would be statistically summarized for different uses of the literature, i.e., one for policy analysis, another for classifying recreation sites, etc.

Table 1 reports the estimates for two specifications for equation (1). The first column includes variables describing the type of site: the economic assumptions made in developing the models and the data-based features (such as the parameter restrictions used, functional form and estimator).

The results indicate that our empirical summary has been exceptionally successful. The type of site and economic assumptions made do matter, as we would expect. In interpreting the signs of the coefficients, note the own elasticity has been entered as a negative value. Somewhat more troublesome is the fact that assumptions without clear connection to economic theory, arising from the data (and therefore the estimator) or the functional specification used for the models also matter. The second column reports the results without these variables. While the effects of the remaining variables are quite stable, we reject this exclusion restriction based on an F-test restricting a subset of the coefficients to zero.

Two types of test results are reported for each estimated parameter--one based on the ordinary least squares covariance matrix and a second that

recognizes the prospect for nonspherical errors. This arises because our sample resembles a panel in that many studies report multiple estimates--either different results for different sites or comparisons of the effects of modeling assumptions. In both cases we might expect some correlation between the estimates. Consequently, we used the Newey-West [1987] variant of White's [1980] consistent covariance matrix to allow for generalized forms of both heteroskedasticity and autocorrelation. These are reported in brackets below the conventional t-ratios and do not change our basic conclusions.

III. Implications

Hotelling's letter offered enormously valuable advice. The travel cost recreation demand model is now widely accepted among resource economists, as well as in federal guidelines for benefit analysis (sea U. S. Water Resources Council [1983] and U.S. Department of Interior [1986]). It is generally regarded as a robust methodology. Our findings suggest that this perception must be interpreted carefully. While the model has been successful for a wide range of applications in estimating plausible demand relationships for recreational sources, a systematic analysis of the record indicates that modeling assumptions do matter. Estimates of the own price elasticity of demand depend on how the issues identified in the current recreation demand literature as important theoretical questions--the measurement of the opportunity cost of time, definition of substitution alternatives and measurement of use (i.e. using trips or days as the dependent variable)--are resolved. They are also affected by decisions that are often data-based with little theoretical justification.

Table 1. Estimated Price Elasticity of Demand from Travel Cost Models:
A **Meta-Analysis**[a]

Variable	Price Elasticity of Demand			
	Full Specification		Excluding Judgemental Variables	
Intercept	1033.99		829.97	
	(7.28)	[4.62]	(5.92)	[4.12]
Qualitative Variable for Measure of Use 1 - trip 0 - per day	2.11 (3.33)	[3.40]	2.45 (4.70)	[3.73]
Qualitative Variables for Type of Site (Overlapping Categories)[b]				
Lake	-.02		-.57	
	(0.05)	[0.05]	(-1.36)	[-1.35]
River	-1.77		-1.80	
	(-2.54)	[-2.381	(-2.27)	[-2.23]
Forest	-3.77		-4.03	
	(-4.74)	[-3.40]	(-4.61)	[-4.66]
State Park	2.28		2.04	
	4.28	2.97	(3.81)	[3.56]
Presence of Substitute Price (-1)	-1.83 (-6.72)	[-5.62]	-.78 (-3.15)	[-1.23]
Use Average Wage Rate to Measure Opportunity Cost of Travel Time **(=1)**[c]	4.25 (4.20)	[2.98]	3.25 (3.28)	[2.55]
Use Family Income per Hour to Measure Opportunity Cost of Travel Time **(=1)**[c]	1.63 (4.18)	[3.12]	1.12 (3.93)	[3.15]
Fraction of Wage Used for Opportunity Cost of Time	-1.72 (-4.39)	[-3.26]	-1.73 (-6.41)	[-4.56]
Regional Travel Cost Model (pooled across set of site -1)	-.68 (-1.49)	[-1.50]		

Table 1 (continued)

	Price Elasticity of Demand		
Variable	Full Specification		Excluding Judgemental Variables
Linear Demand[d] (-1)	2.39 (2.15)	[2.76]	
Log-Linear Demand[d] (-1)	-.22 (-0.20)	[-0.28]	
Semi-Log Demand Dependent Variable[d] (-1)	.67 (0.55)	[0.53]	
OLS[e] (-1)	.22 (0.19)	[-0.30]	
GLS[e] (-1)	.35 (0.31)	[0.52]	
ML-Truncation[e] (-1)	-1.44 (-1.24)	[-1.77]	
Year of the Data Used in Each Study	-.52 (-7.30)	[-4.63]	-.42 (-5.93) [-4.13]
R^2	.65		.45
n	185		185

[a] The numbers in parentheses below the estimated coefficients are the ratios of coefficients to their OLS estimates of the standard errors. Those in brackets use the Newey-West [1987] estimates of the standard errors allowing for a generalized form of heteroscedasticity and autocorrelation.

[b] The omitted category is coastal area and wetlands.

[c] The omitted category is using a wage model to predict an individual specific usage.

[d] The omitted category is a semi-log using independent variables.

[e] The omitted category is a simultaneous equation estimator.

Footnotes

1.   Hotelling's [1947] letter originally described the method as follows:

> Let concentric zones be defined around each park so that
> the cost of travel to the park from all points in one
> of these zones is approximately constant. The persons
> entering the park in a year, or a suitable chosen sample
> of them, are to be listed according to the zone from
> which they came. The fact that they come means that the
> service of the park is at least worth the cost, and this
> cost can probably be estimated with fair accuracy....A
> comparison of the cost of coming from a zone with the
> number of people who do come from it, together with a
> count of the population of the zone, enables us to plot
> one point for each zone on a demand curve for the
> service of the park. By a judicious process of fitting,
> it should be possible to get a good enough approximation
> to this demand curve to provide, through integration,
> a measure of consumers' surplus...

2.   Recent reviews of this literature include Ward and Loomis [1986],
Bockstael, McConnell, and Strand [1989] and Smith [1989].

3.   The classification of published and unpublished is somewhat misleading.
We used the most complete source for developing our estimates and did not include
a separate summary for a thesis that subsequently led to a published paper. In
some cases, unpublished Ph.D. theses have yielded papers after our review was
completed.

4.   There have been several approaches to this problem in the literature. All
impose restrictions on the modeling of recreation decisions, based on a priori
judgments. For example, regional travel cost models restrict the demand
parameters for collections of sites in the same general area to be equal (or
change in systematic ways with specified characteristics). The varying parameter
framework is similar but uses sites drawn from anywhere in the U.S., provided
they supported comparable recreation. The random utility models identify a set
of characteristics and the group of sites assumed to comprise the choice set.
There are other formulations as well. None follows directly from theory. Each
requires a different set of assumptions about how people make recreation
decisions. Our data do not include random utility models. As of 1986, too few
studies used this framework to distinguish it from results based on more
conventional demand models.

5.   The travel cost model is usually described as a derived demand for a
recreation site's services because each visitor produces recreational activities
(e.g., fishing, hiking, swimming, etc.). If we assume the household production
functions for these activities are different, then we would expect differences
in the site demands depending on the activities undertaken.

CHAPTER 3

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CHAPTER 4

NEARLY ALL CONSUMER SURPLUS ESTIMATES ARE BIASED

V. Kerry Smith.

April 4, 1989

Nearly All Consumer Surplus Estimates Are Biased

V. Kerry Smith*

I. Introduction

After eight years of a national mandate for benefit-cost analysis in the evaluation of new major regulations,[1] today benefit measurement is a significant preoccupation of many resource economists. A series of recent papers (beginning with Bockstael and Strand [1987]) have raised important questions about how we evaluate demand models intended for benefit measurement. While the primary focus of this work has been travel cost recreation demand models, the issues they raise are general and equally relevant to benefit measures derived from single equation demand models for any commodity. By recognizing that the consumer surplus estimates are random variables, these authors have argued for greater attention to the construction of interval rather than point estimates, especially when these can reflect the variation in benefit measures arising from estimation uncertainty.

Some authors have maintained that these effects should influence the selection of a functional specification for the demand model. For example, Adramowicz et al. [1989] concluded their simulation analysis approximating the sampling distributions for consumer surplus estimates by suggesting that:

> "...for the linear and semi-log forms price parameter estimates
> close to zero create instabilities, a feature not exhibited by
> the double log and linear log forms. The analyst should be
> aware of this in examining his or her results. Hence, _if two_
> _forms are relatively similar regarding overall fit_ (judged via t
> and F statistics), _but one has a variance of the_
> _associated welfare measure, that form should be selected_"
> (p. 12, emphasis added).

Bockstael and Strand do not consider this issue. They focus instead on what the analyst assumes is the source of the model's error because this source motivates different ways of constructing consumer surplus estimates.

This paper argues that these discussions have overlooked an important aspect of the estimation strategies used in most applied recreation demand modeling. Estimators are selected to provide the "best" estimates of the specified demand function without necessarily considering how these parameter estimates would be used. Indeed, most of the consumer surplus estimates used for policy purposes (see Smith and Kaoru [1988] and Walsh et al. [1988]) are derived from studies that were not specifically intended to derive benefit estimates for the recreation resources they studied. They sought to illustrate new estimators, test hypotheses (e.g., alternative treatments of the opportunity cost of time), or evaluate the effects of functional form. The Adramowicz et al. conclusion suggesting that properties of the consumer surplus estimates should be considered in selecting a final specification for estimated recreation demand models raises a more general issue. If benefit measurement is the objective, shouldn't we use estimators defined to enhance the performance of our welfare estimates rather than modifying the criteria for selecting a functional form to "adjust" for the performance of conventional, "general purpose" estimators with some specifications for demand models?

To motivate further consideration of this question, I develop three points. First, most conventionally estimated demand functions will yield biased consumer surplus measures. Because of these results, the selection of a demand specification solely on the basis of the variability in consumer surplus estimates can be misleading. There is no assurance that tightly clustered

estimates about the wrong central tendency are better than more dispersed estimates about the true value.

Second, I derive an alternative estimator for consumer surplus per unit of use. This new method accepts bias in estimated consumer surplus and seeks to minimize the mean squared error in the consumer surplus per unit of use. The semi-log form is used to illustrate the method because it was found to cause problems in the Adramowicz et al. study and it is the simplest to implement.

Finally, I conclude by discussing issues associated with implementing the estimator and by presenting some evidence from an illustrative Monte Carlo study.

II. Properties of Marshallian Consumer Surplus Estimates

Because the consumer surplus (CS) estimates derived from most popular demand specifications are nonlinear functions of the estimated parameters, they will be biased even if the demand specification is correct! Table 1 illustrates this point using three common specifications for travel cost demand models. The estimated (Marshallian) consumer surplus per unit demanded is reported for each form in the first column.[2] The next two columns report the approximate variance and bias associated with the ordinary least squares (OLS) estimates of these demand models. A second order Taylor Series approximation was used to develop these relationships.[3]

Several aspects of the derivations should be noted. As the first row indicates, the semi-log form requires the least additional assumptions for measures of "average" consumer surplus per unit. The other two forms require further explanation. In the case of the linear form, the sample mean was assumed to be the level of use and was treated as a random variable[4] with the

TABLE 1: Approximate Properties of Consumer Surplus per Unit
Across Demand Specifications

True Model	$\hat{CS}/q$	$Var(\hat{CS}/q)$	Bias $(\hat{CS}/q)$
$\ell nq = \alpha - \beta P + u$	$\dfrac{1}{\hat{\beta}}$	no finite moments[a]	no finite moments[a]
$q = \alpha - \beta P + u$	$\dfrac{\bar{q}}{2\hat{\beta}}$	$\dfrac{\bar{q}^2}{4\beta^2}\left[\dfrac{Var(\bar{q})}{\bar{q}^2} + \dfrac{Var(\hat{\beta})(1+4\beta)}{\beta^2}\right]$	$\bar{q}\,Var(\hat{\beta})$ times $\left[\dfrac{2\beta+1}{2\beta^3}\right]$
$\ell nq = \alpha - \beta \ell n + u$ [b]	$\dfrac{P}{1-\hat{\beta}}\left[k^{1-\hat{\beta}} - 1\right]$	$K_1 Var(\hat{\beta})$	$K_2 Var(\hat{\beta})$

[a]The expressions for the approximate variance and bias of CS/q in the semilog case
are:

$$\dfrac{Var\,(\hat{\beta})}{\beta^4} \quad \text{and} \quad \dfrac{Var\,(\hat{\beta})}{\beta^3} \quad \text{respectively.}$$

However, we know from earlier research (e.g., Bergstrom [1962], Zellner [1978]) that the
maximum likelihood estimator of CS/q will not have finite moments. Closed expressions
for the variance and bias would therefore be incorrect. This outcome reflects one of
the hazards of using approximations to characterize the properties of nonlinear
functions of random variables. This finding does not imply that mesures of the location
and scale parameters of the distributions for alternative estimtaes of CS/q could not be
derived, and thus provides motivation for the sampling results reported later in the
paper.

[b]The definitions for the constants involved in these expressions are given as
follows:

$$K_1 = \dfrac{P}{(1-\beta)^2}(k^{1-\beta} - 1) + \dfrac{P}{(1-\beta)}(-k^{1-\beta}\log k)$$

$$K_2 = \dfrac{1}{2}\left[\dfrac{2P}{(1-\beta)^3}(k^{1-\beta} - 1) - \dfrac{2P}{(1-\beta)^2}(k^{1-\beta}\log k) + \dfrac{P}{1-\beta}k^{1-\beta}(\log k)^2 - \dfrac{P}{1-\beta}k^{-\beta}\right]$$

log-linear form, the choke price was assumed to be a multiple (k) of the price selected for the evaluation, and the quantity is assumed to be the predicted quantity that would correspond to that price. As Adamowicz et al. suggest, there are numerous possible ways of treating the upper price limit used for this case.[5]

These selections imply that the variance and bias for each estimated CS/q measure are not exactly comparable across specifications. This is not crucial to the argument because the objective of the table is to illustrate that even when the true specification is selected (an assumption underlying the derivations in each row of the table), the resulting consumer surplus estimates will be biased. The magnitude of the bias will depend on how each estimate is computed, what is assumed about other potential sources of error, the performance of the estimated demand models in each case, and the true values for the underlying parameters.

The reason why the semi-log form leads to CS/q estimates with substantial estimated variance for small values of β is clear. They do not have finite moments. However, to evaluate whether there would be improvements using another form, one must consider the bias arising when semi-log is the true demand specification and either the linear or log-linear is adopted because of perceived instability in the benefit estimates. This is not reported in the table; it is the information needed to judge the merits of the Adamowicz et al. proposal.

The table does illustrate that the strategy they propose in their concluding remarks (cited above) is inappropriate. The perceived variability in approximate expressions for the scale parameters of $\widehat{CS/q}$, such as the approximation used for the variance, can arise simply as a result of the

magnitude of the true value for β in this relationship for the approximation

for the variance of $\hat{\beta}$. Instead, we should consider how estimators of the

demand function's parameters might be designed to improve the properties of the

consumer surplus estimates they yield.

III. An Alternative Strategy

A simple example based on a variation of an estimator originally proposed

by Theil [1971] can be used to illustrate a different strategy for benefit

estimation. Consider the minimum mean squared error (MMSE), linear estimator

of the consumer surplus. Taking the semi-log specification for the demand

function (which is both most "popular" and regarded as among the most

unstable), a straightfoward derivation of this estimator is possible. In this

case, the estimated $\tilde{CS}/q$, designated now as $\tilde{s}$, is given by $1/\tilde{\beta}$. The general

form for this estimator is given in equation (1). The tilda (-) is used to

distinguish this estimator for β from the ordinary least squares estimator used

in the derivations in Table 1.

$$\tilde{s} = \frac{1}{\tilde{\beta}} = c^T \tilde{q} \tag{1}$$

> where $\tilde{q}$ is a T x 1 vector of observations for the
> log of the quantity demanded of the service of a
> recreation site for each of T individuals measured as
> a deviation from the mean of log q.

If we consider only the case of models with quantity as a function of price, as

in (2), then (3) and (4) describe expected value and variance for $\tilde{s}$ with the

assumption of classically well-behaved errors,

$$\tilde{q} = - \beta \tilde{P} + u \tag{2}$$

> with $\tilde{P}$ a T x 1 vector of travel costs

$$E\ (\bar{s}) = -\beta\ [C^T\tilde{P}] \tag{3}$$

$$\text{Var}\ (\bar{s}) = \sigma^2 C^T C \tag{4}$$

$$\text{where } \sigma^2 I = E(u\ u^T)$$

The mean squared error for $\bar{s}$ is defined in equation (5). After solving the conditions for a minimum of (5), we have equation (6) as one expression for the corresponding estimator.[6]

$$\text{MSE}\ (\bar{s}) = (-\ \beta[C^T\tilde{P}] - \frac{1}{\beta})^2 + \sigma^2 C^T C \tag{5}$$

$$\tilde{s} = -\ \frac{1}{\beta^2}\ (\tilde{P}^T\tilde{P} + \sigma^2/\beta)^{-1}\ \tilde{P}^T\tilde{q} \tag{6}$$

As with the solution to Theil's original problem, the estimator is a function of true values for β and σ^2, which are not observable. Nonetheless, operational counterparts can be defined. For example, Farebrother [1975] proposed that Theil's estimator could be implemented using consistent estimates of β and σ^2 in place of the true values. By an analogous argument, a consistent estimator for $\bar{s}$ can be defined. In what follows, the OLS estimates for β and σ^2 will be used and the estimator designated as the approximate minimum mean squared error method (AMMSE).

Implementing this estimator when the focus is on a single parameter is straightforward and requires no new estimates. Indeed, it can be calculated for virtually all existing studies. To describe the estimator in cases involving multiple independent variables, I use the expression for the OLS estimator derived by partitioning the full set of independent variables into two components with the own price in one and all other specified determinants, including the unit vector for the intercept, in the other. Using the expressions for a partitioned inverse of the moment matrix for the independent

variables and the cross moment with the dependent variable, the OLS estimates of β are given by equation (7) and the AMMSE using OLS to estimate σ^2 and β in (8).

$$\hat{\beta} = (\bar{P}^T M_Z \bar{P})^{-1} \bar{P}^T M_Z q \tag{7}$$

where: Z - matrix of other determinants of demand (including a column of ones for an intercept).

q - vector of the log of quantity (not in deviation form).

$$M_Z = I - Z(Z^T Z)^{-1} Z^T$$

$$\tilde{s} = -\frac{1}{\hat{\beta}^2}(\bar{P}^T M_Z \bar{P} + \hat{\sigma}^2/\hat{\beta})^{-1} \bar{P}^T M_Z q \tag{8}$$

with $\hat{\sigma}^2$ = OLS estimate of σ^2.

With some substitutions, this can be reduced to equation (9):

$$\tilde{s} = -\frac{1}{V_{\hat{\beta}} + \hat{\beta}} \tag{9}$$

where $V_{\hat{\beta}}$ - the estimated variance for $\hat{\beta}$ (i.e., $\hat{\sigma}^2 (\bar{P}^T M_Z \bar{P})^{-1}$)

An argument similar to that of Farebrother can be used to demonstrate that the AMMSE is consistent. However, what is likely to be more relevant for applications is the performance of this type of estimator in small samples.

IV. <u>An Illustrative Sampling Study</u>

To fully describe the comparative performance of OLS versus AMMSE in small samples would require extensive research along the lines of Kling's recent experimental comparisons ([1988a], [1988b]) of random utility versus conventional travel cost demand models. This is beyond the scope of this

paper, so Table 2 offers instead a limited set of experiments that may suggest some of the issues that need to be considered in improving estimates of consumer surplus from travel cost demand models.

Four parameterizations of each model were considered. Two were hypothetical and imply values for s at either end of the range from most applications.   Two correspond to actual estimates for water-based recreation sites taken from Smith and Desvousges [1986].   The key demand parametar for each is reported in the column headings for Table 2 (the intercept was held fixed at 2.33).   Each experiment involves 500 independent replications where OLS and AMMSE (with the OLS estimates as the starting values) are applied to the task of estimating s using samples of 100 observations.   The true models include only the travel cost.   A fixed set of 100 values for travel cost was drawn using the absolute values of random variates drawn from a normal distribution with a mean of 20 and standard deviation of 28.   These were invariant across replications and experiments. The error was assumed to be an independent normal centered at zero with a standard deviation of 5.

Table 2 summarizes the results of these experiments. As Adramowicz et al. suggested and results described as part of the discussion of Table 1 imply, under controlled conditions the OLS estimates of the semi-log demand model (even when it is the correct form) lead to quite variable consumer surplus estimates.   This pattern becomes more pronounced as the absolute magnitude of the price coefficient declines and the corresponding consumer surplus per unit increases.   However, two potentially important qualifications to this pattern seem to warrant further study.

First, the overall pattern (across the 500 replications) for the estimator designed based on the MSE of the consumer surplus per unit is superior to OLS

TABLE 2: Small Sample Properties of OLS and AMMSE: Some Illustrative Experiments[a]

	$\beta = 5$, s = $2.00		$\beta = .0473$, s = $21.14		$\beta = .0125$, s = $80.00		$\beta = 005$, s = $200.00	
	OLS	AMMSE	OLS	AMMSE	OLS	AMMSE	OLS	AAMSE
All Replications								
Mean	2.01	2.01	20.34	22.65	-82.98	8.17	-37.77	0.34
MSE	1.2×10^{-2}	1.2×10^{-2}	6.8×10^{3}	4.7×10^{3}	1.3×10^{6}	5.2×10^{4}	2.7×10^{5}	8.2×10^{4}
n	500		500		500		500	
Postive Values of $\hat{s}$ for OLS								
Mean	2.01	2.01	31.83	32.25	85.80	92.82	105.78	103.24
MSE	1.2×10^{-2}	1.2×10^{-2}	2.3×10^{3}	2.3×10^{3}	1.4×10^{4}	2.0×10^{4}	3.3×10^{4}	3.2×10^{4}
n	500		474		336		273	
Positive Values of $\tilde{s}$ for AMMSE								
Mean	2.01	2.01	30.49	32.32	79.64	93.66	88.75	105.56
MSE	1.2×10^{-2}	1.2×10^{-2}	1.5×10^{3}	2.3×10^{3}	9.4×10^{3}	2.0×10^{4}	2.3×10^{4}	3.2×10^{4}
n	500		473		333		267	

[a] The demand intercept used in these experiments was 2.33. n designates the number of replications used in the summary statistics for each experiment.

for small values of β , considering both the estimated MSE and the bias.
Indeed, the average OLS estimate for CS/q is negative (because of large
negative outlying estimates for s). AMMSE exhibits comparable performance to
OLS for the lowest values of s considered. It dominates OLS in terms of
estimated MSE for s $\approx$ \$21 and based on MSE and bias for larger values of s.

Second, these results are sensitive to the assumed procedure (i.e.
pretesting/estimation strategy) that any summary of the sampling results
assumes analysts would use in evaluating the models involved. It is unlikely
that positive estimates of the own price effect would be accepted in most
applied work. Because these estimates are what give rise to the outlying
negative CS/q estimates for OLS (and AMMSE), a different performance pattern
emerges if we screen estimates and assume these would be rejected. The second
and third sets of results report the summary statistics for OLS and AMMSE when
only positive estimates of CS/q are retained to approximate the sampling
distributions. As the number of replications (n) indicates, negative estimates
for CS/q become more important as the size of β declines.

Now the OLS performance pattern is less negative (and concern over the use
of the semi-log less dramatic). OLS remains superior to AMMSE (regardless of
which is used to screen the samples) until the experiment with the largest true
value for s. Here the record is approximately comparable.

V. Implications

Frequently the applied researcher is warned that data mining, pretesting,
or equivalently the active use of judgment in the evaluation of empirical
models is to be avoided because with this practice, one violates the
assumptions of classical inference and cannot claim conventional properties for

the resulting estimates. While the analytical results underlying this admonition are certainly correct, they imply the sampling properties of the resulting estimators will be <u>different</u> than those attributed to the conventional ("pure") formulations. At a general level, this analysis has suggested that "different" may not mean "worse" in all cases. This may be especially true for nonlinear transformations of the estimates where judgment can eliminate cases that are obviously inconsistent with the theory underlying the model.[7]

A conclusion more specific to my objective is that there seems to be a role for developing estimators based on the economic parameter of interest. This strategy contrasts with one that considers the overall fit of general behavioral models or the properties of all parameters in these models. There are conditions (and in the case of travel cost recreation demands they correspond to a wide range of applications) in which the approximate (linear) minimum mean squared error estimator would have superior properties to the OLS estimate of consumer surplus per unit of use. While these results should be carefully qualified, they do motivate consideration of different strategies for evaluating the stochastic properties of consumer surplus estimates. These alternative approaches should recognize how a model's estimates are to be used and characterize the judgments that are made <u>before</u> these estimates would be accepted for policy applications.